

Metal-silicate-sulfide partitioning of U, Th, and K: Implications for the budget of volatile elements in Mercury

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During formation of the solar system, the Sun produced strong solar winds, which stripped away a portion of the volatile elements from the forming planets. Hence, it was expected that planets closest to the sun, such as Mercury, are more depleted in volatile elements in comparison to other terrestrial planets [1]. However, the MESSENGER mission detected higher than expected K/U and K/Th ratios on Mercury's surface, indicating a volatile content between that of Mars and Earth [2,3].

Our experiments aim to resolve this discrepancy by experimentally determining the partition coefficients ($D^{\text{met/sil}}$) of K, U, and Th between metal and silicate at varying pressure (1 to 5 GPa), temperature (1500 to 1900°C), oxygen fugacity (IW-2.5 to IW-6.5) and sulfur-content in the metal (0 to 33 wt%). Our data show that U, Th, and K become more siderophile with decreasing $f\text{O}_2$ and increasing sulfur-content, with a stronger effect for U and Th in comparison to K.

Using these results, the concentrations of U, Th, and K in the bulk planet were calculated for different scenarios, where the planet equilibrated at a $f\text{O}_2$ between IW-4 and IW-7, assuming the existence of a FeS layer, between the core and mantle, with variable thickness. These models show that significant amounts of U and Th are partitioned into Mercury's core. The elevated superficial K/U and K/Th values are therefore only a consequence of the sequestration of U and Th into the core, not evidence of the overall volatile content of Mercury.

[1] Albarède et al. (2009) *Nature*, 461, 1227-1233. [2] McCubbin et al. (2012) *GRL*, 39, L09202. [3] Peplowski, et al. (2011) *Science*, 333, 1850-1852.